The Soft-Sided Waste Container System

INNOVATIVE TECHNOLOGY SUMMARY REPORT

demonstrated at

Idaho National Engineering and
Environmental Laboratory
Large-Scale Demonstration and
Deployment Project
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ITSR PURPOSE STATEMENT

Innovative Technology Summary Reports (ITSR) are designed to provide potential users with the information they need to quickly determine if a technology would apply to a particular environmental management problem. They are also designed for readers who may recommend that prospective users consider a technology.

Each report describes a technology, system, or process that has been developed and tested with funding from DOE's Office of Science and Technology (OST). A report presents the full range of problems that a technology, system, or process will address and its advantages to the DOE cleanup in terms of system performance, cost, and cleanup effectiveness. Most reports include comparisons to baseline technologies as well as other competing technologies. Information about commercial availability and technology readiness for implementation is also included. Innovative Technology Summary Reports are only intended to provide summary information. References for more detailed information are provided in Appendix A.

Efforts have been made to provide key data describing the performance, cost, and regulatory acceptance of the technology. If this information was not available at the time of publication, the omission is noted.

All published ITSRs are available online at http://em-50.em.doe.gov.

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SECTION 1

SUMMARY

Introduction

The United States Department of Energy (DOE) continually seeks safer and more cost-effective technologies for use in decontamination and decommissioning (D&D) of nuclear facilities. To this end, the Deactivation and Decommissioning Focus Area (DDFA) of the DOE's Office of Science and Technology (OST) sponsors Large-Scale Demonstration and Deployment Projects (LSDDPs). These LSDDPs are managed by DOE's Federal Energy Technology Center (FETC). At these LSDDPs developers and vendors of improved or innovative technologies showcase products that are potentially beneficial to the DOE's projects, and to others in the D&D community. Benefits sought include decreased health and safety risks to personnel and the environment, increased productivity, and decreased cost of operation.

The Idaho National Engineering and Environmental Laboratory (INEEL) LSDDP generated a list of needs statements defining specific needs or problems where improved technology could be incorporated into ongoing D&D tasks. One of the stated needs was for low-level waste (LLW) containers that are more volumetrically efficient, more cost effective, and easier to use. These containers are required to accommodate a variety of D&D debris and maintain container integrity. The typical baseline technologies consist of metal or wooden boxes.

This demonstration investigated the feasibility of using a soft-sided waste packaging system for disposal of LLW debris from D&D activities. Benefits expected from using the soft-sided waste packaging system include:

- Reduced material and operation cost
- Easier to use
- Reduction of void spaces in containers.
- Low landfill subsidence

This report provides a comparative analysis of the cost and performance of the baseline LLW containers and the soft-sided waste packaging system.

Technology Summary

Baseline Technology

Decontamination and decommissioning projects generate a wide variety of LLW debris. Most D&D projects use metal or wooden boxes to containerize LLW for disposal (Figure 1). Typical sizes of wooden containers range from 2 x 4 x 8 to 4 x 4 x 8 ft. The INEEL is currently switching to only allowing metal boxes for LLW disposal on-site. The standard metal box is 4 x 3 x 8 ft and is double lined with reinforced plastic box liners. Metal clips and latches are used to secure these box lids. The metal boxes have an inside capacity of approximately 96 ft^3 and a weight capacity of 8,000 to 10,000 lbs. Metal boxes were used as the baseline for comparison in the demonstration.

Typical D&D containerized LLW includes concrete, cinder block, metal, piping, wood, gravel, soil, and other miscellaneous items. The INEEL disposes of packaged LLW waste, including the container, at the on-site Radioactive Waste Management Complex burial ground. Waste boxes are stacked in the burial pit. Then soil is used to fill between box rows and for cover as the cells are filled.

Innovative Technology

The Transport Plastics Inc., Sweetwater TN, Lift-Liner soft-sided waste packaging system (Figure 2) includes a 25-mil woven outer polypropylene fabric shell with a 2-mil water resistant coating and a 45-mil double layer polypropylene inner liner. The outer shell is equipped with 18 lifting straps made of 2-in. polyester seat belt webbing material. The containers meet the U.S. Department of Transportation requirements for transport of low specific activity and surface contaminated objects (strong tight rule), subject to the requirements of 49 CFR 173.427, 173.410, and 173.24. The system also includes a loading frame used to support the shell and inner

Figure 1. The baseline metal box

Figure 2. The soft-sided waste container empty and full

liner during loading and a lifting frame. The lifting frame attaches to the lifting straps for hoisting the container from the loading frame onto a transport vehicle. A small forklift can move the empty loading frame and lifting frame. The empty containers are light and compact enough to move by hand. Each container is 7 x 8 x 5 ft, has a capacity of 260 ft^3, and holds up to 24,000 lbs.

Demonstration Summary

The technology was demonstrated in August 1998, November 1998, and January 1999 at several INEEL D&D projects. The intermittent nature of the demonstration was because of a site wide INEEL work stand down and implementation of a new work planning process. This delayed the demonstration along with the rest of the D&D work at the INEEL. The test areas for the demonstration were the Central Facilities Area Sewage Treatment Plant and Auxiliary Reactor Area-I D&D projects. These two facilities were selected based on the wide variety of LLW generated during D&D. The Sewage Treatment Plant had sludge drying beds with LLW contaminated sludge, soil, and gravel mix inside of contaminated wooden structures. The large reinforced concrete digester tank was also slated for demolition and disposal as LLW. The Auxiliary Reactor Area-I project was finishing the demolition of a hot cell facility. The outer support areas of the hot cell facility were constructed of reinforced cinderblock and concrete. A significant portion of the waste generated during the Auxiliary Reactor Area-I D&D

was LLW because of a combination of the hot cell facility operations or from contamination spread from a nearby reactor excursion. The projects generated waste and filled the soft-sided containers by the following methods:

- Waste was generated and staged until sufficient quantities were accumulated to fill one or more soft-sided containers
- Waste was placed into a soft-sided container as it was generated.

The method used depended on the type and volume of waste being generated, as well as the overall D&D schedule. In the later stages of the demonstration, the soft-sided containers were being deployed on all INEEL D&D projects and the availability of the two loading frames and lifting platforms dictated how work was performed at some D&D projects.

The soft-sided containers were evaluated against the baseline technology in the areas of cost effectiveness, ease of use, and volumetric efficiency. The demonstration was conducted in the following manner. The soft-sided containers were loaded with a variety of LLW D&D debris to determine the container integrity under a range of circumstances. Then, one waste type was loaded in both the soft-sided containers and the baseline metal boxes to keep the activities as identical as possible to provide valid comparative data. The comparison of the baseline and the soft-sided containers was conducted on the same day, with the same work crew in addition to the same waste. Figure 3 shows full soft-sided containers being removed from the loading frame and stacked for temporary storage.

Figure 3. Lifting full soft-sided waste containers

Key Results

The key results of the demonstration are summarized below; detailed descriptions and explanations of these results are in Section 3 of this report:

- The cost of the soft-sided containers is $365 each. This results in savings of about $1,800 in container cost for each soft-sided container filled versus filing three 4 x 3 x 8 ft metal boxes or four 2 x 4 x 8 ft wooden boxes.
- The soft-sided containers were easier to load because of the large 7 x 8 ft open top and 5 ft depth.
- Larger debris (concrete chunks, piping, etc.) loads into the soft-sided containers, resulting in less waste processing in some cases.
- The soft-sided containers have about three times greater volume and weight capacity than the metal boxes.
- The soft-sided containers reduce void spaces and landfill subsidence.
- Less space is required for empty soft-sided container storage.

- The empty soft-sided containers are easily moved with no special equipment to the job site. Metal boxes require a forklift and flatbed truck every time more boxes are needed.
- There are instances where the baseline technology will be the container of choice because of puncture concerns with some wastes.

Contacts

Technical information on the Lift-Liner Soft-Sided Containers

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Web Site

The INEEL LSDDP Internet web site address is http://id.inel.gov/lsddp

Licensing

No licensing activities were required to support this demonstration.

Permitting

No permitting activities were required to support this demonstration. Both the soft-sided containers and the baseline metal boxes meet the U.S. Department of Transportation requirements in 49 Code of Federal Regulations Subchapter C for IP-1 or strong tight packaging criteria and are suitable for the transport of low specific activity material and surface contaminated objects, subject to the requirements and limitations specified in 49 CFR 173.427, 173.410, and 173.24. The INEEL's Radioactive Waste Management Complex has recently approved the use of the soft-sided containers for LLW disposal. Many commercial facilities currently accept soft-liners from dump trucks or railcars.

Other

All published Innovative Technology Summary Reports (ITSR) are available on the OST Web site at http://em-50.em.doe.gov under "Publications." The Technology Management System, also available through the OST Web site, provides information about OST programs, technologies, and problems.

SECTION 2

TECHNOLOGY DESCRIPTION

Overall Process Definition

Demonstration Goals and Objectives

The overall purpose of this demonstration was to assess the benefits that may be derived from using soft-sided containers for disposal of LLW. The soft-sided containers were compared with the baseline technology, which is metal waste boxes with a double liner. The primary goal of the demonstration was to collect valid operational data so that a legitimate comparison could be made between the soft-sided containers and the baseline technology in the following areas:

- Cost
- Productivity rates
- Ease of use
- Limitations and benefits of both the baseline technology and the innovative technology.

A secondary goal of the demonstration was to provide the D&D program with a better alternative for LLW disposal. To achieve this goal, it was necessary to evaluate the soft-sided containers loaded with a variety of D&D debris.

Description of the Technology

The Transport Plastics, Inc. Lift-Liner System soft-sided containers consist of inner and outer polypropylene containers. The containers are assembled inside of a 7 x 8 x 5 ft steel loading frame. The following sequence is used in setting up the containers, preparing for loading, loading, and removal of the full container from the loading frame:

- The outer container is put into the loading frame and folded open, with flaps outside the loading frame
- The inner liner container is put inside of the outer container and the flaps are folded open over the loading frame
- The waste container is filled
- The flaps of the inner and outer containers are folded shut
- The lifting platform is hoisted into position with a crane
- The container is attached to the lifting platform using the lifting straps on the outer container
- The container is removed from the loading frame and set on the ground
- The straps on the outer container are tied.

The Lift-Liner System containers have a capacity of 24,000 lb. During the demonstration, LLW debris including reinforced concrete, cinder block, metal, piping, wood, gravel, and soil were loaded into these containers (Figure 4).

Figure 4. Filling the soft-sided waste containers with large reinforced concrete slabs.

System Operation

Table 1 summarizes the operational parameters and conditions of the soft-sided container demonstration.

Table 1: Operational parameters and conditions of the soft-sided container demonstration.

Working Conditions	
Work area location	Outside at Central Facilities Area and Auxiliary Reactor Area-I at the INEEL.
Work area access	Access controlled by D&D project through use of fencing and posting.
Work area description	Work area cordoned off by fencing and posted as a radiological controlled area and D&D/construction hazard area requiring training, hard hat, safety glasses, and safety shoes for entry. Both work areas had multiple D&D activities ongoing that were not related to the demonstration. D&D support trailers were available at the job sites.
Work area hazards	Possible loose, low-level radioactive contamination. Heavy equipment operations. Tripping hazards. Strains and sprains from lifting and uneven outdoor surfaces. Temperature extremes.
Equipment configuration	The soft-sided containers and the baseline boxes were both already available on the job site.
Labor, Support Personnel, Specialized Skills, Training	
Work crew	Minimum work crew: • 1 heavy equipment operator (HEO) • 1 equipment operator (EO) • 1 yardman • 1 welder (if rebar or items requiring cutting are present).
Labor, Support Personnel, Specialized Skills, Training (cont'd)	
Additional support personnel	• 1 data taker • 1 Radiological Controls Technician (RCT) • 1 health and safety observer (periodic) • 1 test engineer.
Specialized skills/training	No specialized training was provided, but personnel familiarity with equipment set-up and operation was helpful.
Waste Management	
Primary waste generated	No primary wastes were generated. The demonstration packaged miscellaneous LLW debris for disposal at the Radioactive Waste Management Complex.
Secondary waste generated	Disposable personal protective equipment (PPE).
Waste containment and disposal	All secondary wastes were collected and packaged for disposal with the D&D project waste.
Equipment Specifications and Operational Parameters	
Technology design purpose	LLW waste packaging.
Specifications	• 260 ft^3 capacity • 24,000 lb capacity.
Portability	The empty soft-sided containers can be lifted by one person and set up in the loading frame. The full soft-sided containers require a crane to remove and a truck to haul. A forklift can move the empty loading frame and lifting frame.
Materials Used	
Work area preparation	No specific preparation was necessary for the demonstration. The D&D project already had necessary controls and preparations in place.
Personal protective equipment	Cotton scrubs. Cotton glove liners. 1 pair rubber gloves. shoe covers.
Utilities/Energy Requirements	
Power, fuel, etc.	None required specific to the technology tested. Diesel fuel is required for the heavy equipment used during the demonstration.

SECTION 3

PERFORMANCE

Problem Addressed

Most DOE facilities dispose of LLW in metal or plywood waste boxes. The boxes are not very volumetrically efficient, are costly, and are buried with the waste creating potential subsidence problems in the landfills. The LLW debris generated during D&D is a significant portion of the overall LLW generated at the INEEL. Because of the variety of LLW debris generated, a container that can withstand puncturing, ripping, tearing, etc. is required to meet the demands of the D&D program. The INEEL typically loads a waste container at the project site, stores the full container at the project site until sufficient quantities have accumulated for shipment, and then ships the container to the on-site disposal facility. Therefore, the container must be capable of being moved after it is filled.

The purpose of this demonstration is to use soft-sided waste containers for packaging and disposal of LLW debris generated during D&D. The soft-sided containers will be compared with the performance of the baseline technology, which is metal waste boxes.

Demonstration Plan

Demonstration Site Description

The INEEL's Central Facilities Area Sewage Treatment Plant was constructed and started operations in 1944. The plant treated and disposed of Central Facilities Area wastewater until 1995. The facility consists of several components (septic tank CFA-716, sludge drying bed, and drain field with four distribution areas) constructed by the Navy in 1944 and several components (pumping station CFA-691, sludge drying beds CFA-766, trickling filter, primary and secondary clarifiers, and digester) constructed by the Atomic Energy Commission in 1953. In 1995 an upgraded sewage treatment system was put online. The old Sewage Treatment Plant was shutdown and placed on the surplus list of sites for D&D.

The demonstration area was outside (Figure 5). The LLW contamination at the Sewage Treatment Plant was most likely the result of the operation of a hot laundry at Central Facilities Area for many years. The LLW packaged during the demonstration consisted of dry sludge, soil, gravel, and wood debris from the sludge drying beds; and large chunks of reinforced concrete from the demolition of the digester tank. Only soft-sided containers were filled with debris at the Sewage Treatment Plant. This site provided information on the range of materials that could be packaged in soft-sided containers and ways to improve the loading process.

Figure 5. The Central Facilities Area Sewage Treatment Plant D&D site: digester demolition.

The Auxiliary Reactor Area-I was constructed in the 1950s as a reactor support area. The facility had two primary buildings; ARA-626 that housed hot cells and a decontamination shop and ARA-627 that housed laboratories and materials testing equipment. Numerous smaller buildings (guard station, office trailer, etc.) and structures were also present at the facility. Auxiliary Reactor Area-I ceased operation in 1988 and was vacant until D&D started in the mid-1990s. The D&D completion is planned in 1999.

At the time of the demonstration, the bulk of the structures had been removed from the site and final demolition of the high bay portion of the hot cell facility was underway (Figure 6). The LLW contamination at this site was both the result of hot cell operations and the spread of contamination from the nearby Stationary Low Power-I reactor incident in the early 1960s. The demonstration area was outside at this location also. The LLW used in the demonstration at this site was reinforced cinder block and concrete, which had been stockpiled prior to filling waste containers (Figure 6). The soft-sided containers and the metal boxes were both filled with the same waste at this location to obtain comparative information.

Figure 6. The Auxiliary Reactor Area-I D&D Site: hot cell demolition and cinderblock rubble for loading waste boxes and soft-sided containers.

Major Objectives of the Demonstration

The major objectives were to evaluate the soft-sided containers against the baseline technology in several areas including:

- Cost
- Productivity rates
- Ease of use
- Limitations.

Major Elements of the Demonstration

Both the baseline technology and the soft-sided containers were used to perform "typical" LLW packaging. The intent of the waste packaging was to gather information the D&D project managers needed to make decisions regarding selection of LLW packaging in the future. This demonstration included a wide variety of D&D debris. The common elements of demonstration included:

- Container setup
- Loading reinforced cinder block/concrete rubble
- Container closure
- Container shipping/disposal
- Qualitative assessment of void space
- Worker comments.

In addition, the following elements were performed during the course of the demonstration:

- Identify limitations and benefits of both the baseline technology and the innovative technology

Results

Both technologies were evaluated under identical physical conditions. Every attempt was made to allow work to proceed under normal conditions with no bias. All parties involved in the demonstration were requested to perform the work normally with no special emphasis on speed or efficiency. Both technologies were demonstrated on the same waste type at the Auxiliary Reactor Area-I on January 6, 1999. Additionally, the soft-sided containers were demonstrated on several additional occasions from August to December 1998 at the Central Facilities Area Sewage Treatment Plant. The soft-sided containers were demonstrated under a variety of conditions to adequately assess their durability and full range of use.

During the comparison on January 6, 1999, the LLW debris was the same. Reinforced cinderblock and concrete debris had been stockpiled by the project as D&D progressed. Debris was loaded directly into the waste containers from the stockpile. The tasks performed were basically identical, with variations particular to implementation of the specific technology. In addition to the similar tasks, the same personnel were used for both activities. A performance comparison between the two technologies is provided in Table 2. Figures 7 and 8 shows the loading of the soft-sided containers.

Table 2: Performance comparison between the soft-sided containers and the baseline technology.

Performance Factor	**Baseline Technology 4 x 3 x 8 ft Metal Waste Boxes**	**Lift-Liner System Soft-Sided Containers**
Number of containers filled	Two metal boxes were filled during the head-to-head comparison with the soft-sided containers.	Eight total soft-sided containers were filled during the demonstration. The data collected provided information on the performance of the soft-sided containers under a wide variety of conditions and waste types. One soft-sided container was filled during the head-to-head comparison with the metal boxes.
Personnel/equipment /time required to ready container for loading	Personnel: • 1 EO or HEO • 1 yardman • 1 RCT (RCT filled in as a second yardman when necessary). Equipment: • 1 forklift. Time: • 5 to 6 minutes to move the box into the work zone and remove the lid.	Personnel: • 1 EO or HEO • 1 yardman • 1 RCT (RCT filled in as a second yardman when necessary). Equipment: • 1 forklift. Time: • 2 minutes to move the loading frame into the work zone • 5 minutes to assemble the container inside the loading frame (Note: the 5 minute time is for use of the manufacturer's loading frame that was used during the head-to-head comparison. A frame made at the INEEL for initial testing did not have a hinged frame and required 1 to 2 additional personnel and approximately 15 minutes to setup the container).

Performance Factor	Baseline Technology 4 x 3 x 8 ft Metal Waste Boxes	Lift-Liner System Soft-Sided Containers
Personnel/equipment /time required to fill container	Personnel: • 1 EO or HEO • 1 yardman • 1 RCT (RCT filled in as a second yardman when necessary) • 1 welder (on standby) to cut rebar (the yardman had a welding certificate for the demonstration). Equipment: • 1 excavator or front end loader. Time: • 15 to 17 minutes.	Personnel: • 1 EO or HEO • 1 yardman • 1 RCT (RCT filled in as a second yardman when necessary) • 1 welder (on standby) to cut rebar (the yardman had a welding certificate for the demonstration). Equipment: • 1 excavator or front end loader. Time: • 26 minutes.
Personnel/equipment /time required to close container and move to storage location	Personnel: • 1 EO or HEO • 1 yardman • 1 RCT (RCT filled in as a second yardman when necessary). Equipment: • 1 forklift (with dynamometer to obtain weight). Time: • 5 minutes to shut box • 6 minutes to weigh and move.	Personnel: • 1 HEO • 1EO – spotter • 1 yardman • 1 RCT (RCT filled in as a second yardman when necessary). Equipment: • 1 60 ton crane (with dynamometer to obtain weight). Time: • 1 minute to fold flaps • 6 minutes to hook up loading frame, connect to the container, and lift the container to the ground • 4 minutes to tie down straps on the container • 3 minutes to lift, weigh, and transfer to storage area.
Total Time per Container	• 32 minutes.	• 47 minutes.
Capacity	• 96 ft^3. • 8,000 to 10,000 lb.	• 260 ft^3. • 24,000 lb.
Time to Fill Comparison /Production Rate	• 14.6 minutes per ton (based on 4,960 lb actual box weight). • 339 ft^3 per hour	• 7.2 minutes per ton (based on 14,900 lb actual container weight). • 578 ft^3 per hour
Unit Cost	\$11.20 per yd^3	\$3.44 per yd^3
Waste type	The same waste was used to fill both container types. The waste was reinforced cinderblock and concrete debris that was staged in a pile awaiting containerization.	
PPE requirements	Both technologies required the same level of PPE. The number of workers required to wear PPE is the same for both technologies.	

Performance Factor	Baseline Technology 4 x 3 x 8 ft Metal Waste Boxes	Lift-Liner System Soft-Sided Containers
Superior capability	• The boxes are the preferred container for packaging pieces of contorted, twisted rebar. The soft-sided containers easily handles rebar protruding from concrete and mixed in with other waste. However, the soft-sided containers do not package the loose twisted rebar well. The waste does not compress well and can result in puncturing the soft-sided containers. • If small waste volumes are anticipated, the boxes should be considered because they do not require the mobilization of the crane, lifting/spreader bar, and loading frame.	• Workers considered the soft-sided containers much easier to use. • The soft-sided containers conform to the waste and help decrease the amount of void space (based on visual observations). • The soft-sided containers are more volumetrically efficient. • The soft-sided containers require less waste processing because they can accommodate waste up to 3 ft in diameter.

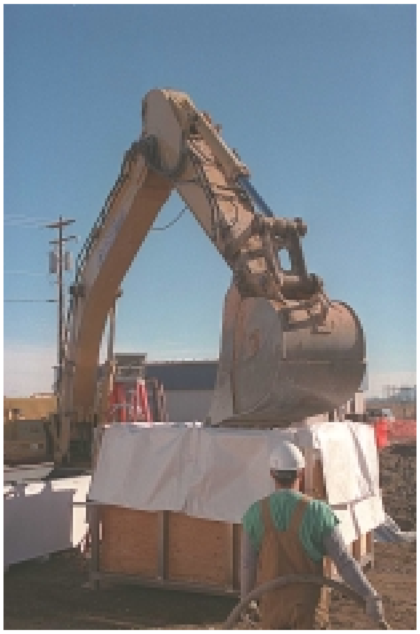

Figure 7. Loading a soft-sided container using a layered approach with soil and gravel between layers of debris.

Figure 8. Removing piping from the digester and loading it in a soft-sided container.

SECTION 4

TECHNOLOGY APPLICABILITY AND ALTERNATIVES

Competing Technologies

Baseline Technology

The baseline technology is metal or wooden waste boxes with a double plastic liner.

Other Competing Technologies

The only other competing technology is railcar or truck liners for LLW shipments. However, these liners are not capable of being lifted and moved around once filled. They do not maintain structural integrity. They are primarily used to prevent spread of contamination to the transport vehicle and prevent loss of waste during bulk transport, rather than as an individual container.

Technology Applicability

The soft-sided containers are a fully developed technology that is now commercially available for LLW packaging. Its superior performance over the baseline in almost all areas makes it a prime candidate technology for deployment throughout the DOE complex. It has the potential to reduce costs for LLW disposal on any D&D project. The INEEL has also deployed these containers on virtually every D&D project for both LLW and asbestos wastes.

Patents/Commercialization/Sponsor

The Lift-Liner System soft-sided containers are commercially available from Transport Plastics, Inc. of Sweetwater, TN. A patent is pending with the U.S. Patent Trade Office.

SECTION 5

COST

Introduction

This section compares the costs for the innovative technology with a baseline technology for containerizing D&D LLW. The innovative technology consists of a 260 ft^3 soft-sided waste packaging system. The baseline containerization method consists of 96 ft^3 metal boxes. The cost to use the innovative technology for the conditions of this demonstration is approximately 31% of the baseline technology cost. This cost analysis is based on observing the loading of one soft-sided container with waste reinforced cinderblock and concrete for the innovative technology, while the baseline involved loading two metal boxes with waste reinforced cinderblock and concrete.

The overall demonstration consisted of loading eight soft-sided containers and two metal boxes. The eight soft-sided containers were filled under a variety of conditions and with numerous types of LLW. This activity was performed to gather information related to the performance of the soft-sided containers under differing conditions. The cost data that are presented in this section are from a head-to-head comparison of filling one soft-sided container and two metal waste boxes. Data from the other seven soft-sided containers were used to supplement the data to make the analysis as representative of conditions as possible.

Methodology

The costs for the innovative and baseline technologies are derived from observed duration of the work activities that are recorded as the demonstration proceeds. During the demonstration, one 260 ft^3 soft-sided container was filled with waste reinforced cinderblock for the innovative technology, while two 96 ft^3 metal boxes were filled with waste reinforced cinderblock for the baseline technology for a total of 192 ft^3. To compensate for the difference in waste debris loaded, the data for the baseline technology was extrapolated to equal 260 ft^3, or approximately three metal boxes.

During the demonstration, the crew varied in size from one to five persons. The fluctuation in crew size reflects crewmembers shifting to other tasks in the general area as the resource requirements for the demonstration changed. The cost analysis makes the assumption that all crewmembers will not be dedicated to waste loading and can be readily shifted to and from other tasks. A typical crew will consist of one heavy equipment operator, one equipment operator, two yardmen and support as needed from one Radiological Control Technician (RCT). In addition, a Field Team Lead (FTL) will oversee the work with some involvement from a Job Site Supervisor (JSS). The cost analysis assumes that the FTL will participate in the prejob briefing and oversee waste loading activities with one-third support from the JSS. It was assumed the supervision of neither the FTL nor the JSS would be required for some of the less complex activities (e.g., warming up the heavy equipment, positioning the flatbed, or getting the waste containers). The labor rates for the crew are based on standard rates for the INEEL Site. The equipment rates are based on the amortized purchase price and maintenance costs. The costs include work delays and inefficiencies that are typical for the work condition of this demonstration. Downtime waiting for the RCT to return to the project and waiting for the crane are specific examples of work delays and inefficiencies observed for this demonstration. These costs are identified in this cost analysis as productivity loss and consist of the accumulated duration of the delays and inefficiencies observed during the demonstration. Additional details of the basis of the cost analysis are described in Appendix B.

Cost Data

Costs to Purchase, Rent, or Procure Vendor Provided Services

The innovative technology is available from the vendor with optional components. The purchase prices of the basic equipment and optional features used in the demonstration are shown in Table 3. Rental of the equipment is available from the vendor.

Table 3. Improved technology acquisition costs.

Acquisition Option	Item Description	Cost
Equipment Purchase	Loading Frame (including shipping) Lifting Frame (including shipping)	$4,650 $5,850
Equipment Rental	Loading Frame Lifting Frame	$200/mo. $450/mo.
Vendor Provided Service		Not Available

Unit Costs

Figures 9 and 10 shows the unit costs (as a percentage of total cost/yd^3) for the innovative and baseline technologies, respectively. The unit costs are based on the costs summarized in Table B-2 and B-3 and include amortization of the equipment purchase and productivity loss. The cost for loading containers with 260 ft^3 of D&D debris for the innovative and baseline technologies was $895 and $2,911, and results in unit costs of $3.44/yd^3 and $11.20/yd^3, respectively. The figures also show a relative contribution to the total for each of the work activities. Activities that occur once per job or once per day have been divided by 260 (the quantity of waste used in this cost analysis) to determine an average unit cost for that activity. The relative contribution of the once per job type of activities will be smaller than shown here for jobs having more than 260 yd^3 of waste and will have a larger percentage for jobs having less than 260 yd^3 of waste (affects the unit cost). Additionally, the site-specific conditions that can significantly affect the cost of the activity are identified on the figure under the title Site Specific Conditions. This section describes the conditions encountered for this demonstration. The percentage information and the condition information provide some indication of the variation in unit cost that may occur at other sites. The activities that are 1 to 5% of the total cost have little affect on the total cost, even if these activities have the potential for large variation. For example, if the radiological survey costs double, there is little impact to the total cost. But, a moderate variation in cost of those activities that are 15% or more of the total unit cost will have a significant impact on the total. For example, a change in the number of container and frame setups or the number of metal boxes used results in a substantial impact on total costs for the innovative and baseline technologies, respectively.

The cost does not account for the potential reduction in space occupied by the soft-sided container in the disposal cell. The soft-sided waste container will conform to the waste shape, reducing void space; whereas a rigid metal box will not allow for any reduction of void space in the disposal facility.

As indicated in Figures 9 and 10, the primary contributor to the unit cost for the innovative and the baseline technology is the material cost for the liner and the box. Consequently, the unit costs will be relatively insensitive to variation in other site-specific parameters.

Payback Period

For the conditions of this demonstration, the innovative technology saves approximately $2,016 per filled soft-sided container over the baseline equivalent of three filled metal boxes. At this rate of savings, the equipment purchase price of $10,500 would be recovered by loading six containers of the innovative technology.

Observed Costs for Demonstration

Figure 11 summarizes the costs observed for the innovative and baseline technology for loading containers with 260 ft^3 of waste debris. The details of these costs are shown in Appendix B and includes Tables B-2 and B-3, which can be used to compute site specific costs by adjusting for different labor rates, crew makeup, etc.

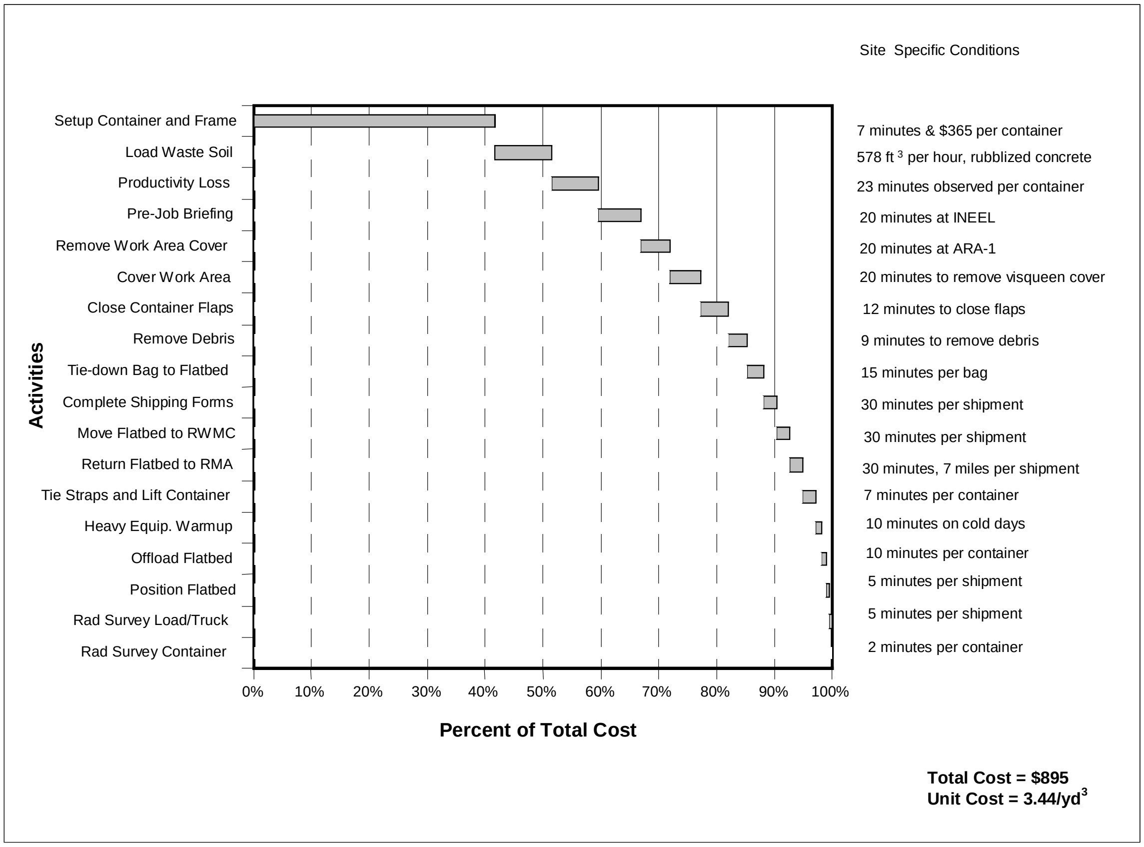

Figure 9. Breakdown of innovative technology unit cost.

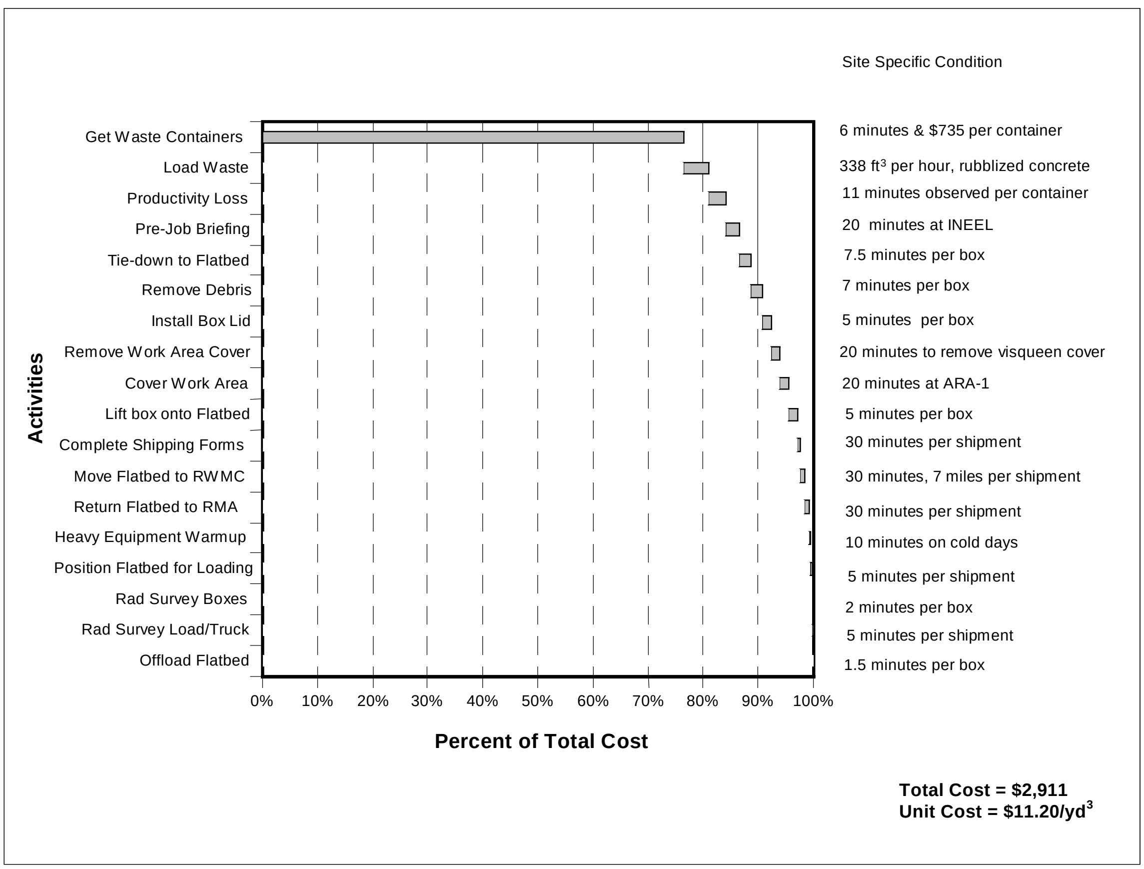

Figure 10. Breakdown of baseline technology unit cost.

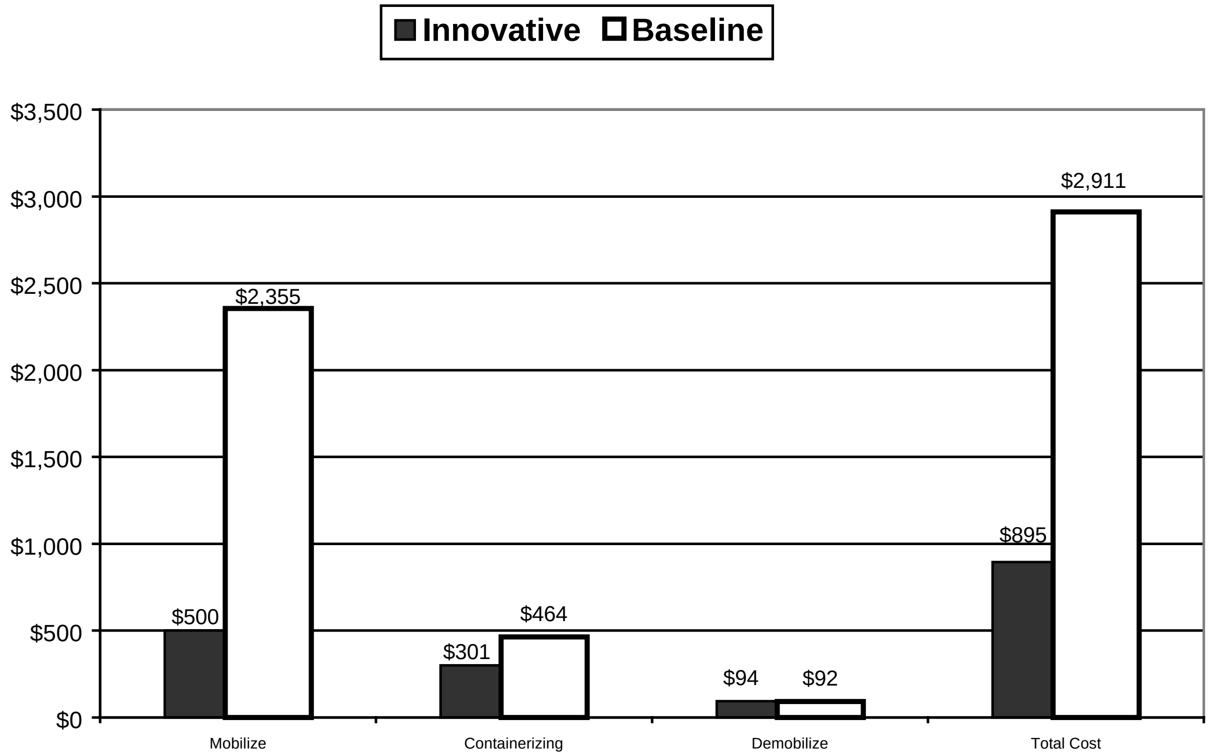

Figure 11. Summary of technology costs.

Cost Conclusions

The innovative technology is approximately 31% of the cost of the baseline technology for this demonstration. The savings result from the innovative technology container being both lower in cost, $365 versus $735 each, and larger in size, 260 ft^3 versus 96 ft^3. The baseline technology required three metal boxes to load the same amount of waste as one soft-sided container for the innovative technology. The production rate for the innovative technology was also higher at 578 ft^3 per hour versus the baseline technology's 339 ft^3 per hour.

The production rates observed during the demonstration were based on loading reinforced cinderblock and concrete debris that had fixed low-level contamination, therefore, requiring no specialized PPE (work was performed with steel toe boots, hard hats, and leather gloves in the head-to-head demonstration). Production rates may vary widely, especially when loading sharp or protruding waste types that may be prone to puncturing the innovative technology container.

In some cases, the waste may be oversized or have sharp projections (particularly rebar). This may require resizing of the waste pieces before loading. An example of cost incurred for resizing is available from a Hanford demonstration. During another large-scale demonstration at Hanford's C Reactor, concrete was resized and loaded at a cost of $81/yd^3 (additional cost not included in this analysis). In situations where waste loading and debris resizing is occurring in highly contaminated areas requiring workers to wear high levels of PPEs, the production rates may be adversely affected as well.

The crew configurations at other sites may be different from the crew assumed in this cost analysis due to differences in the nature of the work and union requirements. In the case of this demonstration, crewmembers shifted from the demonstration to other tasks and back again with relative ease and timeliness, as the resource needs for the demonstration changed. This situation may vary widely between sites with some situations requiring dedicated personnel. In these situations, the costs for productivity losses can be expected to be much higher as the amount of nonworking time for many crewmembers increase.

The cost analysis includes work delays and inefficiencies that are typical for the work condition of this demonstration. Waiting for the RCT to return to the area and downtime while waiting for the crane to arrive are specific examples of work delays and inefficiencies observed for this demonstration. These costs are identified in this cost analysis as productivity loss and consist of the accumulated duration of the delays and inefficiencies observed during the demonstration. The innovative and baseline technologies do not differ in their impact to worker heat stress, fatigue, and stay-time.

Mobilization and demobilization costs will depend upon the distance that the equipment must be moved between the storage area and the work area. In this cost analysis, both the innovative technology equipment and the baseline technology equipment were assumed to be stored in the same location as the work area.

SECTION 6

REGULATORY AND POLICY ISSUES

Regulatory Considerations

The Lift-Liner System soft-sided containers meet the U.S. Department of Transportation requirements for transport of low specific activity and surface contaminated objects (strong tight rule). The soft-sided containers are approved for disposal at the INEEL's Radioactive Waste Management Complex. A test plan, a radiological work permit, and a safe work permit covered their use under the INEEL LSDDP.

Safety, Risks, Benefits, and Community Reaction

Both packaging options have the same basic safety issues associated with their use. The safety issues are primarily heavy equipment/construction hazards and radiation hazards. In both cases the risks are mitigated by use of proper equipment, monitoring, PPE, training, signs, and barriers.

SECTION 7

LESSONS LEARNED

Implementation Considerations

The Lift-Liner System is a mature technology that performed very well during the INEEL demonstration.

The soft-sided containers require no special skills to use. The workers found the soft-sided containers to be much easier to use than the baseline metal boxes. There are several items that should be considered during the use of the soft-sided containers. These recommendations are listed below, along with items that have already been addressed by the manufacturer.

- In loading the soft-sided containers, it is best to put a layer of smaller material in the bottom 6 to 12 in. of the container. This layer provides protection for the bottom of the container when loading debris and allows the container to conform to the waste shape easier. If LLW contaminated soil or gravel is readily available it works very well for this purpose. Otherwise, concrete that has been crushed into smaller pieces and has the rebar removed can be used. Similarly, if large waste items (such as concrete slabs) are put into the soft-sided containers using soil, gravel, or smaller chunks of concrete as fill between bulky layers works well.
- The INEEL started the demonstration with a loading frame that was built onsite for some early testing of the soft-sided containers. The loading frame is rigid and requires two to three workers to assemble the empty containers. A hinged loading frame was purchased from the manufacturer and used during the final part of the demonstration. This frame was much easier to use and had places to secure the lifting and tie down straps so that they do not get "lost" in the loading frame and pinched between the frame and the full container. The use of the manufacturer's frame cut the time necessary to setup an empty soft-sided container from 15 to 5 minutes and only required one worker.
- The soft-sided containers eliminated a lot of hassles for the workers in filling the containers. The waste would typically overflow the sides of the metal boxes during loading. This required the workers to pick up the overflow and place it into the box. Getting the lid on the box was another problem area. It was common to see a worker with a sledgehammer breaking up cinder block and concrete chunks so that the lid could be placed on the box.
- The workers commented that the top flap was difficult to tie if the container was fully loaded, especially if bulky waste was loaded in the soft-sided container. Transport Plastics Inc. has solved this by lengthening the top flap by 1 ft. Additionally, two rows of tie loops have been attached to the outer container. The inner tie loop is used if the container is not at full capacity; the outer loop is used if the container is near full capacity. This allows for good container closure regardless of the fill level. Also, to make the flap closure easier, the tie strap length was increased 18 in. Both of these improvements allow for a total increased tie down length of 30 in. on the top flap.
- In the event of a puncture through the soft-sided container, the approach was to place a temporary patch (duct tape) over the hole if necessary and then place the container inside of another outer liner. It was no problem to lift a full container and put it back into the loading frame to rebag.
- Several soft-sided containers experienced stitching failure of the outside loading straps. Failure occurred after the containers had been allowed to settle and were then hoisted later. The problem appears to be that the end walls are shorter when the top flap is pulled in and tied. This pulls the webbing in further on the end walls and pulls on the straps when lifting. The end wall straps then experience stitching failure. The manufacturer has addressed this problem by sewing the lifting straps down lower on the container walls. This allows for tight closure without restricting the lifting straps.
- The inner liner has gone through several development evolutions by Transport Plastics, Inc. The latest inner liner is a three-layer Canadian manufactured liner. It is more bulky than the previous two layer versions, has a thicker wider weave, is coated on the outside, and is very effective in preventing breaching. The workers strongly preferred this latest inner liner to the previous double-layer versions.

- The manufacturer does not specify any stacking weight restrictions. However, it is recommended that if the soft-sided containers are stacked in temporary storage prior to disposal that containers with similar types of waste be stacked. This is to help prevent shifting.
- The polypropylene will degrade in 1,200 hours based on average sunlight ultra-violet light degradation rate. If the containers are temporarily stored outside for a significant length of time prior to moving them for disposal, it is recommended that they be covered with a tarp.

Technology Limitations and Needs for Future Development

The soft-sided containers performed well during this demonstration. There were no significant technology limitations. Minor problems are discussed above under lessons learned and have already been addressed by the vendor where applicable.

Technology Selection Considerations

Based on the INEEL demonstration, the soft-sided containers are better suited than the baseline technology for most LLW packaging activities. The soft-sided containers are easier to use, more cost effective, more volumetrically efficient, and help reduce landfill subsidence. The following are instances where the baseline technology would be preferable:

- The baseline metal boxes are the best choice if the waste stream is primarily contorted/twisted rebar or similar material that does not compress well and may puncture the soft-sided containers.
- If small quantities of waste will be generated that would make the use of boxes more cost effective than mobilizing the crane for the soft-sided containers.
- Project specific constraints including radiation levels, amount of workspace, etc. should be considered in determining which packaging option best meets project needs.

Figure 12 shows the soft-sided containers being transported for disposal.

Figure 12. Soft-sided containers being transported for disposal.

APPENDIX A

REFERENCES

Thiel, T.N., February 1998, Idaho National Engineering and Environmental Laboratory Document INEEL/EXT-98-00076, Rev. 0, *Health and Safety Plan for the Decontamination and Dismantlement of the Central Facilities Area Sewage Treatment Plant.*

Nelson, R.V., April 1995, Idaho National Engineering and Environmental Laboratory Document INEL-95-0193, Rev. 0, *Health and Safety Plan for Decontamination and Dismantlement of the Auxiliary Reactor Area – I Facility.*

APPENDIX B

COST COMPARISON DETAILS

Basis of Estimated Cost

The activity titles shown in this cost analysis come from observation of the work. In the estimate, the activities are grouped under higher level work titles per the work breakdown structure shown in the ***Hazardous, Toxic, Radioactive Waste Remedial Action Work Breakdown Structure and Data Dictionary*** (HTRW RA WBS) (USACE 1996). The HTRW RA WBS, developed by an interagency group, is used in this analysis to provide consistency with the established national standards.

The costs shown in this analysis are computed from observed duration and hourly rates for the crew and equipment. The following assumptions were used in computing the hourly rates:

- The innovative and the baseline equipment are assumed to be owned by the Government.
- The equipment rates for Government ownership are computed by amortizing the purchase price of the equipment, plus a procurement cost of 5.2% of the purchase price, and the annual calibration costs.
- The equipment hourly rates assume a service life of 5 years for the loading frame and 20 years for the lifting frame.
- The equipment hourly rates for the Government's ownership are based on general guidance contained in Office of Management and Budget (OMB) Circular No. A-94, ***Cost Effectiveness Analysis***.
- The standard labor rates established by the INEEL are used in this estimate and include salary, fringe, departmental overhead, material handling markups, and facility service center markups.
- The equipment rates and the labor rates do not include the Lockheed Martin general and administrative (G&A) markups. The G&A are omitted from this analysis to facilitate understanding and comparison with costs for the individual site. The G&A rates for each DOE site vary in magnitude and in the way they are applied. Decision makers seeking site-specific costs can apply their site's rates to this analysis without having to first back-out the rates used at the INEEL.

The analysis does not include costs for oversight engineering, quality assurance, administrative costs for the demonstration, or work plan preparation costs.

The analysis assumes a 10 hour work day.

Activity Descriptions

The scope, computation of production rates, and assumptions (if any) for each work activity is described in this section.

Mobilization (WBS 331.01)

Prejob Briefing: The duration for the prejob safety meeting is based upon the observed times for similar project activities. The labor costs for this activity are based upon an assumed crew (rather than the actual demonstration participants, and all subsequent activities are based on the assumed crews).

Heavy Equipment Warm-up: This activity is necessary on cold days. The duration is based upon the observed time for the demonstration.

Position Flatbed for Loading: This activity consists of positioning the flatbed truck near the loading area. The duration is based on the observed time for the demonstration.

Remove Tarps/Cover from Work Area: This activity includes the time to remove any required work area covers. The duration is based upon observed times for similar projects.

Setup Empty Container and Frame: This activity includes setting up an empty container and frame next to a waste debris stockpile for filling. The duration is based on the observed time for the demonstration.

Containerization (WBS 331.17)

Don Personal Protective Equipment (PPE): This activity includes the labor and material cost for donning the articles of clothing listed in Table B-1. Neither the innovative nor baseline demonstrations required the use of PPEs, but they may be a cost factor in other situations. The material costs for PPE for each day of use is summarized in Table B-1.

Table B-1. Cost for PPE (per man/day)

Equipment	**Cost Each**	**Number of Times Used Before Discarded**	**Cost Each Time Used ($)**	**No. Used Per Day**	**Cost Per Day ($)**
Rubber overboots (pvc yellow 1/16 in thick)	$12.15	30	$0.41	1	$0.41
Glove liners pr. (cotton inner)	$0.40	1	$0.40	4	$1.60
Rubber Gloves pr. (outer)	$1.20	1	$1.20	4	$4.80
Hoods (yellow)	$6.47	1	$6.47	4	$25.88
Coveralls (white Tyvek)	$3.30	1	$3.30	4	$13.20
Coveralls (green scrubs)	$4.63	1	$4.63	1	$4.63
TOTAL COST/DAY/PERSON					**50.52**

Load Waste: This activity includes loading the waste using a trackhoe at the waste stockpile including a finer layer in the bottom of the soft-sided container. The duration is based upon the observed times for the innovative and baseline demonstrations.

Remove Debris: Debris is removed using trackhoe-mounted jaws or bucket. Rebar ends are cut from debris pieces with a torch.

Radiological Survey Container: This activity includes surveying the loaded container and loading frame.

Close Container Flaps: This activity involves closing the container flaps and attaching the lifting platform to the lifting straps. The container is then lifted from the loading frame using a crane. The container contents are adjusted with hand tools to allow for removal as necessary and the soft-sided container is weighed.

Tie Straps and Lift Container: This activity includes tying the straps around the container, lifting the container with a crane and moving the container to a flatbed.

Tie-down Container to Flatbed: This activity involves tying the containers to the flatbed in preparation for transport.

Radiological Survey the Loaded Flatbed: This activity includes the radiological survey of the flatbed and load prior to transport.

Complete Shipping Forms: This activity covers the time required to fill out the necessary forms and paperwork prior to transport.

Productivity Loss: The cost analysis includes work delays and inefficiencies that are typical for the work condition of this demonstration. Down time waiting for the RCT to return and waiting for the crane are specific examples of work delays and inefficiencies observed for this demonstration. These costs are identified in this cost analysis as productivity loss and consist of the accumulated duration of the delays and inefficiencies observed during the demonstration. The duration is based upon the total time observed for each of the technology demonstrations less the time for those activities directly related to performing work. The net difference is assumed to be the productivity loss. Items specific to the demonstration, such as replacing dead batteries in the camera, are not considered part of normal work and are excluded from the productivity loss calculation. The innovative and baseline technologies do not differ in their impact to worker heat stress, fatigue, and stay-time.

Doff PPE: This activity accounts for the labor costs for doffing PPE in situations where PPEs are required. Neither the innovative nor baseline demonstrations required the use of PPEs.

Demobilization (WBS 331.21)

Move Flatbed to Radioactive Waste Management Complex (RWMC): This activity involves transporting the filled containers to the RWMC.

Offload Flatbed: This activity involves unloading the soft-sided containers or boxes from the flatbed at the disposal area.

Return Flatbed to RMA: Similar to “Move Flatbed to RWMC.”

Cover Work Area: Similar to “Remove Tarps/Cover from Work Area.”

Disposal (WBS 331.18)

Used PPE Disposal: This activity includes the disposal fee for disposal of low-level radioactive solid waste at the cost of $\$150/ft^3$. Neither the innovative nor baseline demonstrations required the use of PPEs.

Decontamination Materials Disposal: This activity includes the disposal fee for disposal of low level radioactive solid waste at the cost of $\$150/ft^3$. The use of decontamination materials was not required for this demonstration, but may be a cost factor in other situations.

Cost Estimate Details

The cost analysis details are summarized in Tables B-2 and B-3. The tables breaks out each member of the crew, each labor rate, each piece of equipment used, each equipment rate, each activity duration, and all production rates so that site specific differences in these items can be identified and a site specific cost estimate may be developed.

Table B-2. Innovative Technology Cost Summary.

Work Breakdown Structure	Unit	Unit Cost $/unit	Quan-tity	Total Cost	Computation of Unit Cost: Pro-duction Rate	Duration (hr)	Labor Item	$/hr	Equipment Items	$/hr	Other $	Comments
Facility Deactivation, Decommissioning, & Dismantlement										**TOTAL COST FOR DEMONSTRATION =**		**$ 894.96**
Mobilization (WBS 331.01)										Subtotal =		$ 500.13
Pre-Job Briefing	ea	65.27	1	$ 65.27		0.33	E,2Y,R,F,1/3J	195.82		0.00		
Heavy Equip. Warmup	ea	9.29	1	$ 9.29		0.17	E	37.10	FT,C,BH,FB	18.66		
Position Flatbed	ea	6.10	1	$ 6.10		0.08	E,Y	69.44	FB	3.70		
Remove Work Area Cover	ea	45.85	1	$ 45.85		0.33	E,2Y,R	137.55		0.00		
Setup Bag and Frame	ea	373.62	1	$ 373.62		0.12	E,Y	69.44	FT,LFT,LDNG	4.42	365.00	Lift-Liner™ bag = $365/bag
Containerizing (WBS 331.17)										Subtotal =		$ 301.39
Don PPE	day	0.00		$ -		0.00		0.00		0.00		No PPEs were required.
Load Waste Soil	ft^3	0.34	260	$ 88.35	578	0.45	E,H,2Y,F,1/3J	195.22	LFT,LDNG	1.12		
Remove Debris	ls	30.04	1	$ 30.04		0.15	E,2Y,R,F,1/3J	195.82	BH,LFT,LDNG	4.42		
Rad Survey Bag	ea	1.24	1	$ 1.24		0.03	R	35.77	LFT,LDNG	1.47		
Close Bag Flaps	ea	42.98	1	$ 42.98		0.20	E,H,Y,R,F,1/3J	202.13	FT,C,LFT,LDNG	12.78		
Tie Straps and Lift bag	ea	20.16	1	$ 20.16		0.12	E,H,Y,F,1/3J	159.62	C,FB,LFT,LDNG	13.19		
Tie-down Bag to Flatbed	ea	23.58	1	$ 23.58		0.25	Y,F,1/3J	90.61	FB	3.70		
Rad Survey Load/Truck	ea	3.29	1	$ 3.29		0.08	R	35.77	FB	3.70		
Complete Shipping Forms	ea	20.40	1	$ 20.40		0.50	E	37.10	FB	3.70		
Productivity Loss	bag	71.35	1	$ 71.35		0.38	E,Y,H,F,1/3J	166.36	LFT,LDNG,BH,FT,C, FB	19.78		
Doff PPE		0.00		$ -				0.00		0.00		No PPEs were required.
Demobilization (WBS 331.21)										Subtotal =		$ 93.45
Move Flatbed to RWMC	ea	20.40	1	$ 20.40		0.50	E	37.10	FB	3.70		
Offload Flatbed	bag	6.80	1	$ 6.80		0.17	E	37.10	FB	3.70		
Return Flatbed to RMA	ea	20.40	1	$ 20.40		0.50	E	37.10	FB	3.70		
Cover Work Area	ea	45.85	1	$ 45.85		0.33	E,2Y,R	137.55		0.00		
Disposal (WBS 331.18)										Subtotal =		$ -
Used PPE	ft^3	0.00		$ -								No PPEs were required.
Decon Materials	ft^3	0.00		$ -								No decon materials.

Labor and Equipment Rates used to Compute Unit Cost

Crew Item	Rate $/hr	Abbrev-eation	Crew Item	Rate $/hr	Abbreve ation	Equipment Item	Rate $/hr	Abbrev-eation	Equipment Item	Rate $/hr	Abbreveation
Yardmen (Welder Cert.)	32.34	Y	Field Team Lead	41.09	F	Crane	8.37	C	Fork Truck	3.30	FT
Radiation Control Tech	35.77	R	Job Site Supervisor	51.53	J	Backhoe	3.30	BH	Lifting Frame	0.35	LFT
Heavy Equipment Oper.	38.65	H				Flatbed	3.70	FB			
Equipment Operator	37.10	E				Loading Frame	0.77	LDNG			

1. Unit cost = (labor + equipment rate) X duration + other costs, or = (labor + equipment rate)/production rate + other costs

2. Abbreviations for units: ls = lump sum; ea = each; and, loc = location; ft^3 = cubic feet.
3. Other abbreviations: PPE = personal protective equipment.

Table B-3. Baseline Technology Cost Summary.

Work Breakdown Structure	Unit	Unit Cost $/unit	Quan-tity	Total Cost	Computation of Unit Cost							Comments
					Pro-duction Rate	Duration (hr)	Labor Item	$/hr	Equipment Items	$/hr	Other $	
Facility Deactivation, Decommissioning, & Dismantlement								**TOTAL COST FOR DEMONSTRATION =**				**$ 2,911.49**
Mobilization (WBS 331.01)										Subtotal =		$ 2,354.81
Pre-Job Briefing	ea	65.79	1	$ 65.79		0.33	H,2Y,R,F,1/3J	197.37		0.00		
Heavy Equipment Warmup	ea	8.16	1	$ 8.16		0.17	H	38.65	FT,BH,FB	10.29		
Position Flatbed for Loadir	ea	6.22	1	$ 6.22		0.08	H,Y	70.99	FB	3.70		
Remove Work Area Cover	ea	46.37	1	$ 46.37		0.33	H,2Y,R	139.10		0.00		
Get Waste Containers	ea	742.76	3	$ 2,228.28		0.10	H,Y	70.99	FT	3.30	735.33	Metal container and shipping costs.
Containerizing (WBS 331.17)										Subtotal =		$ 464.78
Don PPE	day	0.00		$ -		0.00		0.00		0.00		No PPEs were required.
Load Waste	ft^3	0.49	260	$ 126.53	339	0.77	H,2Y,F,1/3J	161.60	BH	3.30		
Remove Debris	box	19.28	3	$ 57.85		0.12	H,2Y,F,1/3J	161.60	BH	3.70		
Install Box Lid	box	16.45	3	$ 49.34		0.08	H,2Y,R,F,1/3J	197.37		0.00		
Rad Survey Boxes	box	1.19	3	$ 3.58		0.03	R	35.77		0.00		
Lift box onto Flatbed	ea	14.03	3	$ 42.08		0.08	H,Y,R,F,1/3J	165.03	FT	3.30		
Tie-down to Flatbed	ea	21.50	3	$ 64.51		0.13	H,Y,R,F,1/3J	165.03	FT,FB	7.00		
Rad Survey Load/Truck	ea	3.29	1	$ 3.29		0.08	R	35.77	FB	3.70		
Complete Shipping Forms	ea	21.18	1	$ 21.18		0.50	H	38.65	FB	3.70		
Productivity Loss	box	32.14	3	$ 96.42		0.18	H,Y,R,F,1/3J	165.03	FT,FB,BH	10.29		
Doff PPE		0.00		$ -				0.00		0.00		No PPEs were required.
Demobilization (WBS 331.21)										Subtotal =		$ 91.89
Move Flatbed to RWMC	ea	21.18	1	$ 21.18		0.50	H	38.65	FB	3.70		
Offload Flatbed	box	1.06	3	$ 3.18		0.03	H	38.65	FB	3.70		
Return Flatbed to RMA	ea	21.18	1	$ 21.18		0.50	H	38.65	FB	3.70		
Cover Work Area	ea	46.37	1	$ 46.37		0.33	H,2Y,R	139.10		0.00		
Disposal (WBS 331.18)										Subtotal =		$ -
Used PPE	ft^3	0.00		$ -								No PPEs were required.
Decon Materials	ft^3	0.00		$ -								No decon materials.

Labor and Equipment Rates used to Compute Unit Cost											
Crew Item	**Rate $/hr**	**Abbrev-eation**	**Crew Item**	**Rate $/hr**	**Abbreve ation**	**Equipment Item**	**Rate $/hr**	**Abbrev-eation**	**Equipment Item**	**Rate $/hr**	**Abbreveation**
Yardmen (welder Cert.)	32.34	Y	Field Team Lead	41.09	F	Fork Truck	3.30	FT			
Radiation Control Tech	35.77	R	Job Site Supervisor	51.53	J	Backhoe	3.30	BH			
Heavy Equipment Oper.	38.65	H				Flatbed	3.70	FB			

1. Unit cost = (labor + equipment rate) X duration + other costs, or = (labor + equipment rate)/production rate + other costs
2. Abbreviations for units: ls = lump sum; ea = each; and, loc = location; ft^3 = cubic feet.
3. Other abbreviations: PPE = personal protective equipment.

APPENDIX C

ACRONYMS and ABBREVIATIONS

Acronym/Abbreviation	**Description**
D&D	Decontamination and Decommissioning
DDFA	Deactivation and Decommissioning Focus Area
DOE	United States Department of Energy
EO	Equipment Operator
FETC	Federal Energy Technology Center
ft	Feet
FTL	Field Team Leader
G&A	General and Administrative
HEO	Heavy Equipment Operator
hr	Hour
in	Inch
INEEL	Idaho National Engineering and Environmental Laboratory
IP-1	Industrial Package Level 1
ITSR	Innovative Technology Summary Report
JSS	Job-Site Supervisor
lb	Pounds
LSDDP	Large Scale Demonstration and Deployment Project
LLW	Low-Level Waste
OMB	Office of Management and Budget
OST	Office of Science and Technology
PPE	Personal Protective Equipment
RCT	Radiological Control Technician
RMA	Radioactive Materials Area
RWMC	Radioactive Waste Management Complex
USACE	United States Army Corps of Engineers
Yd^3	Cubic yard